

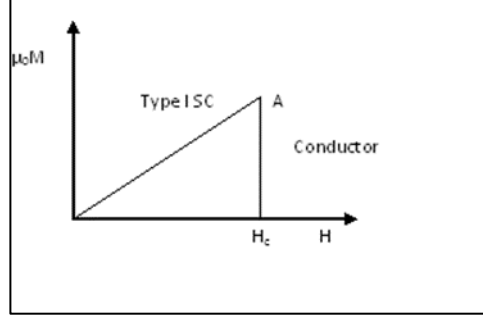
## CHAPTER 1

### INTRODUCTION

#### 1.1 BACKGROUND OF THE PROBLEM

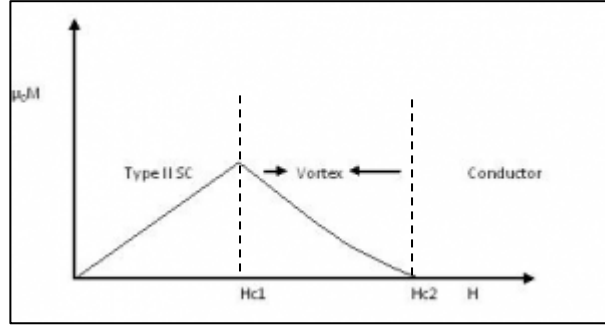
Superconductivity is study about materials that offers no electrical resistance that is zero resistivity,  $R = 0$  and expels magnetic fields, or show perfect diamagnetism ( $B_{\text{inside}}=0$ ) when the material is cooled to adequate temperature (normally in liquid helium temperature range). In 1911, K. Onnes observed the behaviour of superconductivity of mercury in liquid helium and he noticed that the resistance disappeared below critical temperature  $T_c \sim 4$  K. Critical temperature of several materials such as lead (Pb), aluminum (Al) and some alloys have been discovered. High temperature of an oxide superconductor, LaBaCuO recorded at 77 K was found by Georg Bednorz and Alex Muler (1986) and it strongly depends on their structure.

Generally, superconductors are divided into two types; Type-I and Type-II. In Type-I, the superconductors must be kept at below critical temperature,  $T_c$  to ensure the magnetic susceptibility stay at negative one (-1) and based on Figure 1.1, the critical field,  $H_c$  higher than applied field,  $H$ . But the superconductivity can be destroyed if the applied magnetic field is stronger than critical magnetic field,  $H > H_c$ , the magnetic field are able to penetrate into superconductor causes an extinguish of the superconducting state and it no longer be superconductor (perfect conductor) even though the temperature below critical temperature,  $T_c$  and this phenomena show Type-I superconductor perfectly obeys Meissner effect. Meissner effect describe the properties of superconductor where superconducting materials creates current which oppose the magnetic field inside the superconductor. Walther Meissner and Robert Ochsenfeld found Meissner effect in superconductors which is also known as perfect diamagnetism ( $B_{\text{inside}} = 0$ ).



**Figure 1.1:** The magnetization versus applied magnetic field for Type-I superconductor

Besides, Type-II superconductor can behave like Type-I superconductor (Meissner phase) as shown in Figure 1.2.  $H < H_{c1}$  the magnetic field destroyed magnetic flux and magnetization inside superconductor become zero. Nonetheless, at one point the applied magnetic field,  $H$  reaches the critical magnetic field,  $H_{c1}$  the magnetic fluxes enter uniformly and slowly start loses the superconductivity. When  $H_{c1}$  passed upper critical magnetic field,  $H_{c2}$ , the superconductivity behavior completely disappears. This is called 'mixed state' ( $H_{c1} < H < H_{c2}$ ) in which quantized vortices flux penetrates the material without demolishing superconductivity. The addition of nanoparticles or impurities can be increased the current density,  $J_c$  that act as flux pinning center.



**Figure 1.2:** Magnetization versus applied magnetic field for type II superconductor.

## 1.2 PROBLEM STATEMENT

Copper oxide based superconductor ( $\text{YBa}_2\text{Cu}_3\text{O}_7$ ) at the normal state can be applied at electronic device but we cannot use in application because the critical current density,  $J_c$  is too low. Regarding this issue, the addition of magnetic nanoparticles,  $\text{Co}_{0.5}\text{Ni}_{0.5}\text{Fe}_2\text{O}_4$  into  $\text{YBa}_2\text{Cu}_3\text{O}_7$  is needed to increase the critical temperature to be used for various type of application. Furthermore, due to low critical current density  $J_c$  in Type-II superconductor, the vortex motion different amount of magnetic nanoparticles might change critical current density,  $J_c$ , critical temperature,  $T_c$ , microstructure and Meissner effect of  $\text{YBa}_2\text{Cu}_3\text{O}_7$  superconductor compared to electrical properties in pure YBCO.

In the other hand, in order to measure the electrical properties of superconductor, four point probe must be developed in FIST laboratory in Universiti Malaysia Pahang. Four-point probe technique is easy and fast method to measure the direct current (DC) resistance in superconductor.